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L2	latc$ and L1	0	L2
L1	(composite adj flexure$) and (carbon adj fib$)	5	L1

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LATCAO	2
LATCARRYOVER	1
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LATCAU-ALEXANDRU	1
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1. Document ID: US 6632310 B2

L1: Entry 1 of 5 File: USPT Oct 14, 2003

US-PAT-NO: 6632310
DOCUMENT-IDENTIFIER: US 6632310 B2

TITLE: Disk drive actuator and method of making same

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw Desc | Image

2. Document ID: US 6350286 B1

L1: Entry 2 of 5 File: USPT Feb 26, 2002

US-PAT-NO: 6350286
DOCUMENT-IDENTIFIER: US 6350286 B1

TITLE: Prosthetic ankle and walking system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw Desc | Image

3. Document ID: US 6174595 B1

L1: Entry 3 of 5 File: USPT Jan 16, 2001

US-PAT-NO: 6174595
DOCUMENT-IDENTIFIER: US 6174595 B1

TITLE: Composites under self-compression

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC | Draw Desc | Image

4. Document ID: US 5826304 A

L1: Entry 4 of 5 File: USPT Oct 27, 1998

US-PAT-NO: 5826304
DOCUMENT-IDENTIFIER: US 5826304 A

TITLE: Composite flexure unit

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
Draw Desc | Image

5. Document ID: US 5800568 A

L1: Entry 5 of 5 File: USPT Sep 1, 1998

US-PAT-NO: 5800568
DOCUMENT-IDENTIFIER: US 5800568 A

TITLE: Prosthetic ankle and walking system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
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Term	Documents
COMPOSITE	235051
COMPOSITES	40221
CARBON	555408
CARBONS	45855
FLEXURE$	0
FLEXURE	26764
FLEXUREAND	4
FLEXURECONTROLLABLE	1
FLEXURED	95
FLEXURED-EXTESION	1
FLEXUREL	1
((COMPOSITE ADJ FLEXURE$) AND (CARBON ADJ FIB$)).USPT.	5

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Previous Page Next Page

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L1: Entry 1 of 5 File: USPT Oct 14, 2003

DOCUMENT-IDENTIFIER: US 6632310 B2
TITLE: Disk drive actuator and method of making same

Abstract Text (1):
The present invention relates to a laminated actuator assembly and the method for making the actuator assembly. The actuator assembly is intended for use in miniature personal electronic devices, but could be used in any type of disk drive. The actuator is primarily constructed from strong, stiff, lightweight composite materials. The upper and lower planar elements of the actuator assembly, each comprising multiple composite layers, include a forward portion and a rearward portion. A flexure member, typically positioned between the layers of composite material, allows the forward portion of each planar element to pivot in unison relative to the rear portion of each planar element. In this manner, the position of an optical pick up unit or other read/write device positioned at the distal end of the actuator assembly can be adjusted relative to the surface of a data disk. The composite and flexure planar elements are formed in arrays of multiple component pieces with aligned registration members. The registration members provide accurate alignment during assembly. Adhesive is applied in appropriate quantities to fully fill the space between the upper and lower layers, without seepage at the edges. By assembling the actuator components in arrays, the miniature actuator assemblies can be easily handled and the electronic, optic and magnetic subassemblies can be attached more easily.

Brief Summary Text (8):
One embodiment of the present invention is a laminated actuator assembly comprising three or more planar elements, with most of those planar elements comprising carbon fiber composite material made of several layers. These multi-layer carbon fiber composite planar elements are separated by a central planar element comprising a flexure and spacer. The number of individual layers or plies comprising the planar elements may vary. Fiber orientation among the various carbon fiber layers is selectively and strategically placed through the thickness of the carbon fiber planar element to align with principal axes of the beam elements of the actuator arm in order to optimize particular objectives, such as bending and twisting stiffness.

Brief Summary Text (9):
One of the planar elements also comprises a flexure member. The flexure member allows the forward portion of the actuator assembly to pivot relative to the rear portion of the actuator assembly, allowing an optical pick up unit disposed on the distal end of the actuator assembly to move relative to the surface of an optical disk for purposes of maintaining focus on the information layer of the disk. The flexure member is preferably made from a lightweight, flexible metal having a high yield strength and can be formed from either an etching, stamping or die cutting process. The flexure member may be positioned adjacent the outer surface of a carbon fiber planar element, or it may be positioned between two carbon fiber planar elements. In those instances when the flexure member is disposed between carbon fiber planar elements, a spacer also may be included to maintain appropriate spacing between carbon fiber planar elements directly separated by the flexure. The spacer provides for a more uniform adhesive layer in the completed laminated actuator assembly. The flexure member footprint does not necessarily have to match the footprint of the carbon fiber planar elements. Similarly the footprints of the carbon fiber planar elements may vary. Such variability facilitates attachment of other components, such as the optical pickup unit and flex circuit.

Brief Summary Text (11):
The fiber laminate planar elements provide the structural characteristics of the actuator assembly. These planar elements, or upper and lower composite planar elements when viewed relative to the surface of the disk, are manufactured in arrays of multiple component pieces. More specifically, a number of layers of fiber material are combined to form a composite planar element panel. A water jet or other appropriate cutting device, under computer control, cuts the composite planar element panel into an array of multiple copies of the upper and lower fiber planar elements, still attached to the exterior frame of the overall lamination panel. For efficiency and handling, the component pieces remain attached to the overall lamination panel in an array format. In addition, registration points are also formed in each panel for subsequent use in aligning the panel to the corresponding arrays of components in mating panels during subsequent processing. The panels of flexure elements include similar registration features for co-alignment with the panels of upper and lower carbon fiber planar elements.

Detailed Description Text (4):
FIGS. 2-4 provide additional views of the actuator arm 10, with the optical pickup unit, voice coil motor assemblies and bearing cartridge removed. The forward and rearward portions 12, 14 of the actuator arm 10 of the preferred embodiment are each comprised of an upper planar element 36 and a lower planar element 38 with a flexure member 40 and spacer member 42, comprising a third planar element 44, disposed between the upper and lower planar elements. In the preferred embodiment, as partially illustrated in FIG. 5, both the upper and lower planar elements 36, 38 comprise eight separate layers or plies of carbon fiber material L.sub.1 -L.sub.8 made from composite planar element panels 58, although the number of layers or plies comprising the overall laminate structures which are the planar elements 36, 38 may be more or less, provided symmetry about the neutral axis of the planar element is generally maintained. In particular, each carbon fiber layer L.sub.1 -L.sub.8 of the planar elements 36, 38 has a distinct geometry and purpose such that the resulting carbon fiber planar element can take advantage of the separate benefits of the individual layers. In this regard, the fibers within each layer are oriented to optimize the purpose of the layer and each layer can form a uniaxial fiber matrix. For example, fibers are oriented parallel to the orientation of beam elements to provide desired stiffness and the fibers of different layers cross at high enough angles with respect to the other individual layers to provide an overall laminate structure which is stiff in some directions and flexible in others. Generally, the fibers are parallel to each other within each carbon fiber layer L.sub.1 -L.sub.8, but the orientation of the fibers from layer to layer in an overall planar element of the actuator assembly may vary.

Detailed Description Text (5):
In the planar elements having eight carbon fiber layers, the fibers in each layer are approximately 0.002 inches in diameter. In addition, in four of the eight layers L.sub.1, L.sub.2, L.sub.7, L.sub.8, the fibers have a zero degree orientation, meaning the fibers are aligned parallel to the longitudinal axis A.sub.L of the actuator arm 10 as shown in FIG. 6. Two of these zero degree oriented layers L.sub.1, L.sub.2, are the upper most layers and two of the zero degree oriented layers L.sub.7, L.sub.8, are the lower most layers of the planar elements 36, 38. The fibers in the center four layers L.sub.3 -L.sub.6, are oriented alternately at plus or minus 29 degrees relative to the longitudinal axis A.sub.L. This orientation is shown in FIG. 6 at A.sub.+29 and A.sub.-29. Twenty-nine degree fiber orientation is selected because it is the orientation of arm segments 24 and 26 relative to the long axis of the actuator arm. By orienting the fibers of these layers L.sub.3 -L.sub.6 to be parallel to the orientation of arm segments 24, 26, these arm segments or beam elements are stiffened with respect to bending. The layers L.sub.1 -L.sub.8 are arranged symmetrically by their fiber orientation to avoid curling of the composite planar element panels 58 and planar elements 36, 38. The varying fiber orientation of the layers also gives greater strength to the overall structure and helps reduce or eliminate damage to the planar elements 36, 38 during handling and assembly. Also, it is desirable to carefully control the quantity of resin within each fiber layer L.sub.1 -L.sub.8. By matching the thickness of the individual layers L.sub.1 -L.sub.8 as close as possible to the diameter of the fibers, the strength of the laminated layers, and thus the fiber planar element, increases.

Detailed Description Text (6):
Carbon is the preferred fiber because it has among the highest ratios of stiffness to density. For example, the specific gravity of a carbon fiber planar element is approximately 1.8, very near that of magnesium, but will have a Young's modulus of approximately 50 million pounds per square inch, whereas magnesium has a Young's modulus of approximately 7 million pounds per square inch. By way of comparison, steel has a Young's modulus of 30 million pounds per square inch, but a specific gravity of 7.8. Thus, a carbon fiber planar element is approximately four times less dense than steel, but is sixty-seven percent stiffer.

Detailed Description Text (10):
For purposes of manufacture, eight layers or plies of carbon fiber material L.sub.1 -L.sub.8, with the fibers preferably substantially oriented at a predetermined angle (see FIGS. 5, 6), are joined together to form a single carbon fiber laminate or panel 58, as shown in FIG. 5. Arrays of upper and lower planar elements 36, 38 are cut into the laminated panel 58 to form cut panels 78 and 80 (see FIGS. 10, 11). The number of individual component pieces to be cut in an array may vary. The embodiment shown in the drawings have six upper or lower planar elements 36, 38 per array. Ideally, a computer or numerically controlled water jet is used to cut the component footprints in each panel 58. Alternatively, similarly controlled milling machines can cut the array of component pieces from the panel 58. A water jet, however, is not only faster, but is much more cost effective than milling machines. Where a milling machine utilizes a cutting tool that wears out and needs regular replacement, a water jet has no such problem. Moreover, a water jet can cut multiple panels 58, creating multiple copies of cut panels 78 and 80 at one time, thereby further increasing output. FIGS. 10 and 11 illustrate arrays of six upper and lower planar elements 36, 38 cut into two panels 58 of eight laminated carbon fiber layers, respectively. At the same time as the water jet, or other methods known and available to those skilled in the art cut the arrays of upper and lower planar elements 36, 38, registration members, such as holes 60, are also cut in the panels 58. The purpose for cutting the registration holes 60 at the same time as the component structural pieces are cut is to reduce subsequent errors in alignment when assembling and bonding the multiple planar elements into an actuator arm. In this manner, the only error is that which would result due to the CNC cutting process, but not to the alignment of the planar elements when combined. Alternatively, the individual layers L.sub.1 -L.sub.8 may be separately cut to form arrays of component pieces and then laminated to form panels 78, 80 of planar elements 36, 38 or uncommon cuts in each layer L.sub.1 -L.sub.8 can be made individually and all common cuts can be made following lamination of the multiple layers into a single planar element. The process of forming registration features in each layer would be the same in order to enhance accurate alignment of the individual layers L.sub.1 -L.sub.8.

Detailed Description Text (11):
In general terms, a method of assembling the actuator of the present invention will now be described. As illustrated in FIGS. 5 and 6, depicting a first embodiment, eight carbon fiber layers L.sub.1 -L.sub.8 are combined to form the upper and lower panels 58, which are then cut to create cut panels 78, 80, from which fiber planar elements 36, 38 will result. Each layer L.sub.1 -L.sub.8 is impregnated with epoxy for bonding the individual layers together. The combined structure is placed in an autoclave under appropriate pressures and temperatures to activate the epoxy and secure the layers L.sub.1 -L.sub.8 into a laminate panel 58. In connection with the preferred embodiment, the temperature is approximately 325.degree. F. and the applied pressure is approximately 50 pounds per square inch.

Detailed Description Text (12):
Following the autoclave procedure, the laminated panels 58, are cut, by means of water jet or other appropriate techniques, into an array of upper and lower carbon fiber planar elements 36, 38 of the actuator arm 10 in panels 78 and 80. Alternatively, the cutting of component pieces within the individual layers L.sub.1 -L.sub.8 may be done prior to bonding the layers together or some of the cut may be made in individual layers and the remaining cuts are made in the overall laminated panel. At this point, registration features 60 are also accurately located and cut into the panels 78, 80. Similarly, an array of flexures 40 are cut from metallic or

other appropriately flexible material into a panel 62 which will mate with a pair of upper and lower fiber planar panels 78, 80. Also, an array of spacers 42 are cut from appropriate material into a panel 66, which will also mate with the pair of upper and lower fiber planar panels 78, 80. The flexure and spacer panels 62, 66 also have aligned registration features, such as apertures 60, to match those in the carbon composite planar panels 78, 80. In the cutting process, a number of sprues 70 are left between the planar elements 36, 38 and the surrounding panels 78, 80, as well as between the flexures 40 and spacers 42 and the remaining panels 62 and 66 respectively. The registration holes 60 maintain alignment among the panels 62, 66, 78 and 80 during further processing. It should be appreciated that other methods of providing registration among the various panels can be used instead. For example, alignment may be achieved by using panel edges or corners, or by optically detecting identified fiduciaries on the panel or by bearing bores.

Detailed Description Text (13):
At this point, the panels 62, 66, 78 and 80 are ready to be combined into an actuator arm assembly. The upper and lower carbon fiber panels 78, 80 containing planar elements 36, 38, are placed on a clamping fixture, such as vacuum chuck 72 (FIG. 13). The registration pins 74 on the chuck 72 mate with the registration holes 60 in the panels 78, 80 and properly co-align the panels. Vacuum pressure through slots 76 hold an upper and lower planar element panels 78, 80 in position for application of adhesive. Silk screen techniques are then used to apply adhesive to both the upper and lower fiber planar element panels 78, 80. FIG. 14 illustrates a chuck 72 with a lower panel 80 of planar elements 38 positioned on registration pins 74 and an upper panel 78 of planar elements 36, also intended to be positioned on chuck 72 but elevated from the surface of the chuck 74 for illustration. A silkscreen 82, showing the openings for the pattern of adhesive to be applied, is also shown. The silkscreen also includes registration holes 84 for aligning the silkscreen 82 relative to the panels 78, 80. It should be appreciated however, that other techniques may be utilized to apply adhesive, including but not limited to application by roller, spray, other printing or as a film.

Detailed Description Text (17):
While various embodiments have been shown and described, it will be apparent that other modifications, alterations and variations may be made by or will occur to those skilled in the art to which this invention pertains, particularly upon consideration of the foregoing teachings. For example, the number of layers or plies within the fiber planar elements may vary as may the relative orientation of the fibers within each layer. In addition, while carbon fiber composite material performs well in this application, other materials such as glass, magnesium, boron, beryllium, Kevlar and ceramics, alone or in various combinations may also perform satisfactorily. It is also contemplated that the component shapes may be cut from individual layers of material, which layers are subsequently laminated to form a composite panel, or that the component shapes are cut from the composite panel. It is still further contemplated that the individual layers comprising a planar element may have varying shapes and sized relative to each other. The objective is to achieve a lightweight, but a strong and stiff actuator assembly. It is therefore contemplated that the present invention is not limited to the embodiments shown or described in such modifications and other embodiments as incorporate those features which constitute the essential functions of the invention are considered equivalent and within the true spirit and scope of the present invention.

Other Reference Publication (1):
IBM Corp: "Carbon Fiber Reinforced Metal Matrix or Polymer Composite E-block", Research Disclosure, vol. 42, No. 425, Sep. 1999.

CLAIMS:

9. The method of claim 1, wherein the composite fiber material includes carbon fiber.

10. The method of claim 9, wherein the carbon fibers have a diameter of approximately 0.002 inches.

L1: Entry 2 of 5 File: USPT Feb 26, 2002

DOCUMENT-IDENTIFIER: US 6350286 B1
TITLE: Prosthetic ankle and walking system

Abstract Text (1):
An inventive prosthetic ankle for use between a pylon and a prosthetic foot to support a person's weight on the ground comprises an integrally formed, generally C-shaped carbon-fiber composite flexure member having upper, lower and curved legs. The upper leg is connected to a lower end of the pylon, and the lower leg is connected to an upper surface of the prosthetic foot. The curved leg interconnects the upper and lower legs, with the curved leg extending from a forward edge of the upper leg to a forward edge of the lower leg in a rearwardly-facing arc about a medial/lateral axis positioned forward of the pylon. The curved leg is dog-boned to facilitate canting of the pylon with respect to the prosthetic foot in the medial/lateral plane. Also, the curved leg is resilient to resiliently bias the upper and lower legs apart from one another so the legs are positioned in a spaced-apart relationship with respect to one another when the person's weight is off the prosthetic ankle. The resilient biasing also allows the upper and lower legs to pivot toward one another about the medial/lateral axis when the person's weight is on the prosthetic ankle at heel strike. As a result, the prosthetic foot falls flat on the ground soon after heel strike. A limit strap coupled between the upper and lower legs limits rotation of the upper and lower legs away from each other about the medial/lateral axis so the flexure characteristics experienced by an amputee during step-off are substantially determined by the flexure characteristics of the toe portion of the prosthetic foot.

Detailed Description Text (2):
A preferred prosthetic ankle 10 shown in FIG. 3 includes a generally C-shaped carbon-fiber composite flexure member 12 having an upper leg 14 connected to a conventional upper attachment plate 16 with a bolt 18. The bolt 18 extends through a hole in the upper attachment plate 16 and into an upper insert nut 20 inserted into a hole in the flexure member's upper leg 14. A lock washer 22 prevents the upper insert nut 20 from turning when the bolt 18 is tight. The upper attachment plate 16 is connectable to a lower end of a conventional pylon (not shown) in a known manner. Although the present invention will be described with respect to a carbon-fiber composite flexure member, a variety of other materials will also work for purposes of this invention. For example, steel, plastic, DELRIN.RTM., nylon and aluminum will work.

Detailed Description Text (5):
The flexure member's curved leg 32 preferably assists in making the prosthetic ankle 10 more or less rigid at toe-off. This allows the toe-off flexure characteristics experienced by an amputee using the prosthetic ankle 10 to be substantially determined by the toe portion of a prosthetic foot (not shown) attached to the prosthetic ankle, as will be described in more detail below. The prosthetic ankle 10 can do this by, for example, having a curved leg 32 constructed with the angle of the carbon fibers in the curved leg 32 varying from being parallel with the upper and lower legs 14 and 24 at the inside surface of the curved leg 32 to being perpendicular with the upper and lower legs 14 and 24 at the outside surface of the curved leg 32. This allows the flexure member's curved leg 32 to rigidly resist rotation of the flexure member's upper and lower legs 14 and 24 away from one another about the medial/lateral axis 34 past their low-load parallel position. Of course, a wide variety of other well-known carbon-fiber composite construction

techniques will also work for this purpose.

CLAIMS:

3. The prosthetic ankle of claim 1 wherein the flexure member is made with a carbon-fiber composite material.

4. The prosthetic ankle of claim 3 wherein the carbon-fiber composite material is formed to allow the curved leg to limit rotation of the upper and lower legs away from each other about the medial/lateral axis so the flexure characteristics experienced by the person during step-off are substantially determined by the flexure characteristics of the toe portion of the prosthetic foot.

15. The prosthetic ankle of claim 14 wherein the flexure member is made with a carbon-fiber composite material.

16. The prosthetic ankle of claim 15 wherein the carbon-fiber composite material is formed to allow the curved leg to limit rotation of the upper and lower legs away from each other about the medial/lateral axis so the flexure characteristics experienced by the person during step-off are substantially determined by the flexure characteristics of the toe portion of the prosthetic foot.

26. The prosthetic ankle of claim 25 wherein the flexure member is made with a carbon-fiber composite material.

27. The prosthetic ankle of claim 26 wherein the carbon-fiber composite material is formed to allow the curved leg to limit rotation of the upper and lower legs away from each other about the medial/lateral axis so the flexure characteristics experienced by the person during step-off are substantially determined by the flexure characteristics of the toe portion of the prosthetic foot.

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L1: Entry 4 of 5 File: USPT Oct 27, 1998

DOCUMENT-IDENTIFIER: US 5826304 A
TITLE: Composite flexure unit

Abstract Text (1):
A composite flexure unit 10, 10', 120 includes a flexure member (12, 12', 12", 100) comprising a low modulus of elasticity material. The flexure unit (10, 10', 120) includes a first portion (22, 122) for mounting the flexure (12, 12', 12", 100), a second portion (32, 124) for mounting the flexure, and a third portion (40, 121) connecting the first portion (22, 122) to the second portion (32, 124). The flexure (12, 12', 12", 100) is bendable about a rotational axis passing through the third portion (40, 121) of the flexure member. A tension load bearing element (18A, 18B, 18C, 18D, 18E, 18F, 18G, 120) comprising a high modulus of elasticity material provides longitudinal strength and stiffness to the flexure (12, 12', 12", 100) without significantly increasing flexion stiffness about the rotational axis (14) is incorporated with the flexure.

Brief Summary Text (2):
The present invention relates to flexure units, and more particularly, to a composite flexure unit for use as a hinge joint.

Brief Summary Text (6):
The present invention relates to a composite flexure unit which includes a flexure member comprising a low modulus of elasticity material. The flexure includes a first portion having a first mounting mechanism therein for mounting the first portion of the flexure, a second portion having a second mounting mechanism therein for mounting the second portion of the flexure, and a third portion connecting the first portion to the second portion. The flexure is bendable for pivoting about a rotational axis passing through the third portion. A load bearing element comprises a high modulus of elasticity material for providing longitudinal strength and stiffness to the flexure, without significantly increasing flexion stiffness about the rotational axis is used in conjunction with the flexure member (by locating that element in close proximity to or on the neutral plane of bending of the flexure member).

Drawing Description Text (2):
FIG. 1 is a perspective view of a composite flexure of the present invention showing a first tensile load bearing element;

Drawing Description Text (3):
FIG. 2 is a perspective view of a composite flexure of the present invention showing a second tensile load bearing element;

Drawing Description Text (4):
FIG. 3 is a perspective view of a composite flexure of the present invention showing a third tensile load bearing element;

Drawing Description Text (5):
FIG. 4 is a perspective view of a composite flexure of the present invention showing a fourth tensile load bearing element;

Drawing Description Text (6):
FIG. 5 is a perspective view of a composite flexure of the present invention showing

a fifth load bearing element;

Drawing Description Text (7):
FIG. 6 is a side elevational view of a composite flexure with a first cover plate arrangement;

Drawing Description Text (8):
FIG. 7 is a side elevational view of a composite flexure with a second cover plate arrangement;

Drawing Description Text (12):
FIG. 11 is a front elevational view of the composite flexure showing a second cover plate arrangement; and

Detailed Description Text (2):
Referring to FIG. 1, a composite flexure unit, indicated generally at 10, includes a flexure 12 comprised of a low modulus of elasticity material which is operable about a rotational axis 14 which is typical of any axis in the transverse plane and an elongated load bearing element 18 for providing longitudinal strength and stiffness to the flexure 12 without significantly increasing flexion stiffness of the flexure 12 across a longitudinal bending plane, indicated by arrow 16. The bending plane 16 lies perpendicular to axis 14 and parallel to the longitudinal axis of the element 18.

Detailed Description Text (4):
The load bearing element 18 is made of a material having a high modulus of elasticity, such as a metal, glass, or carbon fiber for providing longitudinal strength and stiffness to the flexure unit 10. The load bearing element 18 has a low bending cross-sectional modulus of elasticity, referring to bending it in any plane of its longitudinal axis. In the case of an ankle-foot orthosis, that could be in a direction of dorsiflexion/planterflexion of a patient's ankle. Thus, the load bearing element 18 provides minimal resistance to flexure bending about axis 14. The load bearing element 18 is located in or parallel to the bending plane 16 of the encapsulating flexure 12 and confined to that location to provide a minimal effect on resistance to planterflexions and dorsiflexions. Embedding the slender load bearing element 18 (tension load carrying as shown) within the thicker, stubbier, encapsulating column of material forming flexure 12 in the location noted, preserves the bending compliance of the flexure unit 10 and provides protection to the load bearing element 18. The tensile load bearing element 18 is protected from concentration of shear and bending stresses and from direct blows which might otherwise nick, scratch, or in other ways damage or dislodge the slender load bearing element 18 from its advantageous location.

Detailed Description Text (5):
The first and second mounting devices 22 and 32 each include a nut 41, a bolt 42 and possibly, a sleeve 60 having hole 43 through which the bolt 42 passes for fastening the composite flexure 10 to an orthosis shell 28 or other structure (See FIGS. 10 and 11). It should be apparent to those skilled in the art that other mounting devices may be used, such as, a rod., pin, nail or screw. A first end 44 of the tension load-bearing element 18 is looped around the sleeve 60 of first mounting device 22 and a second end 54 of the load bearing element 18 is looped around the sleeve 60 of the second mounting device 32 such that the load bearing element 18 is secured within the flexure 12.

Detailed Description Text (7):
When used as orthotic components or in other applications, the composite flexure 10 is sometimes subjected to large repeated tension loads which have the potential of causing fatigue cracking of the tensile load bearing element 18, typically in the area of fixation to the mounting devices 22 and 32. The potential for such fatigue damage and failure depends directly on the magnitude of the peak loading experienced by the load bearing element 18. Also, where the tensile load bearing element 18 mates with the mounting devices 22 and 32, there is a tendency for some rotational and translational relative motion between the tensile load bearing element 18 and the supports such as sleeves 60 which as shown are held by mounting bolts 42. The relative motion causes wear and/or fretting which degrades the mounting and

accelerates the fatigue damage. The shock absorbing sleeves 60 positioned between the respective ends of tension bearing element 18 and the bolts 42 or other mounting devices reduces both peak tension loading and the probability of wear. Additional shock absorption may be provided by using a tensile load bearing element 18 which is of extra length and strung loosely between the first and second mounting devices 22 and 32. As the flexure unit 10 is loaded longitudinally the tensile load bearing element 18 is pulled taut to provide shock absorption.

Detailed Description Text (9):
Referring to FIG. 2, the load bearing element is shown in the form of a very thin tension strap 18A having a wide cross-section with the width dimension being parallel to axis 14 and perpendicular to the bending plane 16 of the orthotic joint. The loop portions 44 and 54 of the strap 18A are sewn (or welded, in the case of a metal strap) onto themselves to fasten the strap 18A between the mounting devices 22 and 32, respectively. Given equal tension load carrying capability, the strap design of the tension bearing element may be configured to have a lower bending stiffness than the cylindrical cable of FIG. 1. However, the strap design may require more care during installation to assure that the bending planes of composite flexure pairs 10 are aligned with each other. The other parts of this form of the invention are the same as and function the same way as described in connection with FIG. 1.

Detailed Description Text (13):
Referring to FIGS. 6-9, the orthotic shell 28 or other structure to which the composite flexure units 10 are mounted may be configured to surround or wrap around an outer surface of the composite flexure 10 so as to reduce the magnitude of unwanted modes of transverse shear deflections and rotation. In orthotic applications, the orthotic shell 28 has a recess 72 (See FIGS. 8 and 9) for receiving the ends of composite flexure unit 10. The first and second portions 20 and 30 of the flexure 12 are surrounded and restrained by the surfaces forming recess 72 on the front 73, back 74, and side 75 surfaces of the flexure 12, as shown in FIG. 8. A cover plate 80 comprised of a high modulus of elasticity material completes the surround/restraint function of the orthosis shell 28. The cover plate 80 covers an outer surface 76 of each of the ends of flexure 12 to further reduce the unwanted translational and rotational motions of the flexure 12 without restricting motion in the bending plane 16. The cover plates 80 are installed as part of the mounting devices 22 and 32 to spread the loads created by the flexure 12 on the mounting device 22 and 32 over a greater area. The cover plates 80 may be etched away or relieved as shown at 80A on either the front or rear in the third portion 40 of the flexure 12 to restrict planterflexion or dorsiflexion (See FIGS. 7 and 9) by providing stop surfaces. The cover plates may be etched away or relieved as shown at 80B on both the front and rear in the third portion 40 (See FIG. 6) to permit two way flexion or reverse bending.

Detailed Description Text (16):
Another embodiment of the composite flexure unit 10' of the present invention is illustrated in FIG. 12. The load bearing element 18F is not encapsulated along the centerline of the third portion 40 of the flexure 12', rather it is offset significantly to one side of the portion 40A. The load bearing element 18F creates a bending compliance bias between dorsiflexion and planterflexion. The degree of bias may be varied by a tension adjustment mechanism 90 before, during, and/or after installation of the composite flexure unit 10' to create a bending bias on the flexure 12'. The tension adjustment mechanism 90 includes a loop portion 92 which is looped around and fixed to the sleeve 60 of the first mounting device 22 and a tightening member 94 for shortening the tension member 18F and thereby biasing the load bearing member 18F. The tightening member 94 is accessible from the outer surface of the flexure 12' and may be a cam or a gear driven screw combination for adjusting the tension. Another practical approach to varying the bias would be to produce flexure units with various amounts of non-adjustable bias.

Detailed Description Text (19):
When used in pairs to create an orthotic or other joint (or hinge), rotation of the composite flexure unit 10', shown in FIG. 12, about the rotational axis 14 may be assisted or resisted. Rotational motion stops 95 (see FIGS. 6 and 7) formed by abutting surfaces on the two relatively movable parts of the orthotic shell 28 may be used if desired with the biased (or biasable) composite flexure unit pairs 10' to

create virtually any desired combination of rotational motion management. The stops also can be eliminated if desired. Tensioning or shortening the tensile load bearing element 18F with the tension adjustment mechanism 90 when the element 18F is positioned posterior of the portion 14A of flexure 12' would create a planterflexion assist bias. If the composite flexure 10' was reversed 180.degree. so that the load bearing element 18F was positioned anterior of the portion 14A of low modulus flexure 12', tensioning or shortening will create a dorsiflexion assist bias. Thus, for example, by managing installation alignment of the composite flexure, such that the composite flexure unit 10' is biased for dorsiflexion and by placing a stop on the parts of the orthosis shell 28 to prevent planterflexion, the composite flexure unit 10' may function like a spring-loaded hinge, biased to assist dorsiflexion and block plantarflexion. Other combinations of ankle motion assistance and limitation are easily achieved.

Detailed Description Text (21):
In FIGS. 14 through 21 a further composite flexure unit 100 (FIG. 21) is illustrated. The composite flexure unit 100 is preferably made with a load bearing element of strands of fibers or threads of oriented tetrafluoroethylene, sold under the trademark TEFLON. Oriented Teflon is essentially a fine Teflon fiber or thread that is stretched under conditions that orient the molecules along the length of the fiber to reduce its elongation characteristics under load and increase the tensile elastic modulus and strength of the fiber. The material is commercially available and the diameter size can vary. However, the thread preferably is quite fine for the application shown, to reduce the overall size of the composite flexure 100 while maintaining adequate tensile strength. One existing use for this fiber or thread is as a dental floss sold by Colgate-Palmolive Co.

Detailed Description Text (27):
The finished tension load bearing element (FIG. 20), including the two sleeves (104 and 108) is placed in a suitable fixture and encapsulated in a low modulus of elasticity material, such a polyurethane, shown at 121. The preferred configuration of the finished composite flexure unit 100 is as shown in FIG. 21.

Detailed Description Text (33):
FIGS. 22 and 23 show an orthotic shell 28' or other structure, to which the composite flexure units 10 are mounted, configured to provide a recess for receiving a flexure unit. This is similar to the construction shown in FIGS. 6-9. In FIG. 22, the upper portion 28A of the orthotic shell 28' has a molded-in recess 72A and the lower portion 28B of the orthotic shell 28' has a recess 72B. These recesses are of size to receive the ends of a composite flexure unit 125, constructed such as that shown at 10' in FIG. 12, or the unit shown in FIG. 13 with .beta. equal to 0.

Detailed Description Text (34):
End portions 126A and 126B of the composite flexure unit 125 are surrounded on three sides by the surfaces forming the recess, and are secured in place with a suitable pin 128.

Detailed Description Text (35):
The recesses 72A and 72B are created with the use of a molding dummy configured with a .beta. angle equal to a minus value, -25.degree. for instance. This angle, -25.degree. for instance, corresponds to the angle indicated by the line with double arrows at 131. A composite flexure unit that has load bearing member offset from the center portions of the flexure unit as shown is formed to be "at rest" with the flexure straight as shown, the offset angle of the recess 72B will cause the forward end of the lower shell portion 28B to tilt upwardly and provide a bias force useful for "toe lift". In use when the lower shell is supporting a foot, the shell rear parts will move toward or to the dotted line position shown in FIG. 22 and this will provide a preload on the load bearing member shown at 131 in FIG. 22. As stated previously, choosing one of several different angle differences between the angle of the center line of one or both recesses formed by a molding dummy when the orthotic shell is molded, and the angle .beta. of the flexure, which is shown in FIG. 13, one can choose different levels of preload and angular motion bias.

CLAIMS:

1. A composite flexure unit for hingedly joining two relatively movable parts together about a hinging axis comprising, a first part having a first edge, a second part having a second edge adjacent the first edge;

the flexure unit comprising:

a flexure member comprising a first material having low modulus of elasticity properties so as to permit flexing about the hinging axis, the flexure including a first end portion having a first mounting portion therein for mounting a first end of the flexure to the first part, a second end portion of the flexure member having a second mounting portion therein for mounting a second end of the flexure member to the second part, and a third portion of the flexure member connecting the first portion to the second portion, the flexure member providing the hinging axis passing through the third portion of the flexure member which is substantially between the edges of the first and second relatively moving parts on which the flexure is mounted; and

a load bearing element comprising a second material having a modulus of elasticity substantially greater than the first material coupled to the mounting portions of the flexure element and carrying tension loads between the mounting portions and being selected in cross sectional size to bend about the hinging axis without significantly increasing flexion stiffness about the hinging axis, the load bearing element comprising a multi-strand element formed of fiber wrapped around and extending between first and second end sleeves forming the first and second mounting portions to form two multi-strand lengths of fibers, the fibers being of a material having a low coefficient of friction, and the fibers on the multistrand lengths being free to slide relative to one another, and being operable with the flexure member to carry tension loading between the first and second mounting portions.

2. The composite flexure of claim 1, wherein the load bearing element is encapsulated within the first, second and third portions of the flexure.

3. The composite flexure of claim 1, wherein the load bearing element comprises oriented tetrafluoroethylene.

4. The composite flexure of claim 1, wherein the two multi-strand lengths extend between the end sleeves, and wherein the multi-strand lengths cross in center portions between the end sleeves to form a FIG. 8 pattern.

5. The composite flexure of claim 4 and an overwrap of a fiber length wrapped around the multi-strand lengths along a major portion of the distance between the end sleeves to form a bundle of fibers.

6. The composite flexure of claim 1, further comprising a first cover plate positioned on the first portion of the flexure, and a second cover plate positioned over the second portion of the flexure, the first and second cover plates being placed to overlie the respective end portion of the flexure and engaging a surface of the end portion facing outwardly from the recess, the cover plates having a modulus of elasticity sufficiently high to restrict bending and shear so as to occur only in the third portion of the flexure, and being operable with the first and second mounting portions, respectively, for restraining the end portions and spreading loads created by the load bearing element to an area defined by the first and second cover plates.

7. A composite flexure unit comprising in combination:

a flexure member comprising a material having a low modulus of elasticity that is flexible and bends about a hinging axis, the flexure member including a first portion having a first sleeve thereon for mounting a first end of the flexure member, a second portion having a second sleeve thereon for mounting a second end of the flexure member, and a third portion connecting the first portion to the second portion, the flexure member being bendable about a rotational axis passing through the third portion of the flexure member when the first and second ends are mounted to relatively movable members; and

a tension carrying link positioned between the first and second portions of the flexure member and comprising two multistrand lengths of a substantially continuous fiber of oriented polytetrafluoroethylene wrapped around and extending between the first and second sleeves in the first and second portions, the lengths of fiber crossing at a center location between the end sleeves, and an overwrap of fiber around the lengths to form the lengths into a bundle for providing longitudinal strength and stiffness to the flexure unit without significantly increasing flexion stiffness of the third portion about the rotational axis, and wherein strands of fiber making up the multistrand lengths are free to slide relative to other strands of fiber in the same multistrand length.

8. The composite flexure of claim 7 in combination with a shell having two parts that are held for pivoting movement by the flexure unit and means for mounting the first and second portion of the flexure member to the two parts, the mounted flexure unit being oriented to provide a bias in one direction of pivoting from a reference position.

9. The composite flexure of claim 7 wherein the material having a low modulus of elasticity comprises polyurethane molded around the tension carrying link at least in the first and second portions.

10. A composite flexure unit for hingedly joining two relatively movable parts together about a hinging axis comprising a first part having a first edge, and a second part having a second edge adjacent the first edge, the flexure unit comprising:

a flexure member comprising a first material having low modulus of elasticity properties so as to permit flexing about the hinging axis, the flexure member including a first end portion having a first mount for mounting a first end of the flexure to the first part, and being restrained from moving relative to the first part, a second end portion having a second mount for mounting a second end of the flexure member to the second part, and being restrained from moving relative to the second part, and a third portion of the flexure member connecting the first portion to the second portion, the flexure member providing the hinging axis passing through the third portion of the flexure member which is substantially between the edges of the two relatively moving parts on which the flexure member is mounted; and

a load carrying element comprising multiple strands of fibers of a second material having low coefficient friction properties and having a modulus of elasticity substantially greater than the first material, the multiple strands being wrapped around and extending between the first and second mounts to form two multistrand tension carrying lengths of fiber, the lengths being selected in cross sectional size to bend about the hinging axis without significantly increasing flexion stiffness about the hinging axis, the load carrying element hinging with the flexure member, and the strands of fiber making up the multistrand tension carrying lengths being free to slide relative to other strands of fiber in the same multistrand length.

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L1: Entry 5 of 5 File: USPT Sep 1, 1998

DOCUMENT-IDENTIFIER: US 5800568 A
TITLE: Prosthetic ankle and walking system

Abstract Text (1):
An inventive prosthetic ankle for use between a pylon and a prosthetic foot to support a person's weight on the ground comprises an integrally formed, generally C-shaped carbon-fiber composite flexure member having upper, lower and curved legs. The upper leg is connected to a lower end of the pylon, and the lower leg is connected to an upper surface of the prosthetic foot. The curved leg interconnects the upper and lower legs, with the curved leg extending from a forward edge of the upper leg to a forward edge of the lower leg in a rearwardly-facing arc about a medial/lateral axis positioned forward of the pylon. The curved leg is dog-boned to facilitate canting of the pylon with respect to the prosthetic foot in the medial/lateral plane. Also, the curved leg is resilient to resiliently bias the upper and lower legs apart from one another so the legs are positioned in a spaced-apart relationship with respect to one another when the person's weight is off the prosthetic ankle. The resilient biasing also allows the upper and lower legs to pivot toward one another about the medial/lateral axis when the person's weight is on the prosthetic ankle at heel strike. As a result, the prosthetic foot falls flat on the ground soon after heel strike. A limit strap coupled between the upper and lower legs limits rotation of the upper and lower legs away from each other about the medial/lateral axis so the flexure characteristics experienced by an amputee during step-off are substantially determined by the flexure characteristics of the toe portion of the prosthetic foot.

Detailed Description Text (2):
A preferred prosthetic ankle 10 shown in FIG. 3 includes a generally C-shaped carbon-fiber composite flexure member 12 having an upper leg 14 connected to a conventional upper attachment plate 16 with a bolt 18. The bolt 18 extends through a hole in the upper attachment plate 16 and into an upper insert nut 20 inserted into a hole in the flexure member's upper leg 14. A lock washer 22 prevents the upper insert nut 20 from turning when the bolt 18 is tight. The upper attachment plate 16 is connectable to a lower end of a conventional pylon (not shown) in a known manner. Although the present invention will be described with respect to a carbon-fiber composite flexure member, a variety of other materials will also work for purposes of this invention. For example, steel, plastic, DELRIN.RTM., nylon and aluminum will work.

Detailed Description Text (5):
The flexure member's curved leg 32 preferably assists in making the prosthetic ankle 10 more or less rigid at toe-off. This allows the toe-off flexure characteristics experienced by an amputee using the prosthetic ankle 10 to be substantially determined by the toe portion of a prosthetic foot (not shown) attached to the prosthetic ankle, as will be described in more detail below. The prosthetic ankle 10 can do this by, for example, having a curved leg 32 constructed with the angle of the carbon fibers in the curved leg 32 varying from being parallel with the upper and lower legs 14 and 24 at the inside surface of the curved leg 32 to being perpendicular with the upper and lower legs 14 and 24 at the outside surface of the curved leg 32. This allows the flexure member's curved leg 32 to rigidly resist rotation of the flexure member's upper and lower legs 14 and 24 away from one another about the medial/lateral axis 34 past their low-load parallel position. Of

course, a wide variety of other well-known carbon-fiber composite construction techniques will also work for this purpose.